PCT Patent Application

Heater Fan with Integrated Flow Control Element

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Priority

This application claims priority from US 60/520,668 (High Performance Micro Fans with Dual Redundant Fan Technology) filed November 18, 2003.

Field of Invention

This invention relates to a unique configuration of series fans for high performance heaters. The configuration utilizes an integrated flow control element or diffuser between the two fans to substantially remove the swirl component of flow before it enters the secondary fan, allowing the secondary fan to operate at a level of efficiency which may approach or even exceed that of the primary fan. Further, the integrated flow control element may be configured as a heater element. As a result, the configuration offers excellent performance in a very compact format. There are several related applications in the consumer products and automotive fields.

Background

There is a large and growing market high performance compact heaters. Current products are based on a traditional design that includes a heater element and a fan. The heater element adds heat to the airflow, but also introduces a drag component that reduces the output of the fan(s). The present invention, on the other hand, teaches an integrated heater and integrated flow control element that adds heat to the airflow while simultaneously increasing the output of the fans. The use of two fans also increases the safety of he product since the heater will continue to function in the event of a single fan failure.

Operation

An axial fan works best if it sees a flow with no swirl on the input side. This condition is met with a single fan since there is nothing on the input side to generate swirl. However this is not the case with a normal series fan configuration since the output of the first fan unfortunately has a swirl component as depicted in Figure 4 (with reference to the following components and corresponding numbers). The combined airflow is directed through an external heater element before it is allowed to leave the system.

Component	*Number*
Primary fan	2
Primary air flow with swirl	3
Secondary fan	4
Secondary air flow with swirl	13
External heater element	15

(With reference to Figure 4)

This problem may be resolved by placing an integrated flow control element, or diffuser, between the two fans, the result of which is to reduce or substantially remove swirl from the air flowing into the secondary fan. This increases the efficiency of the secondary fan to a level approaching that of the primary fan, creating an efficient series fan configuration. Note that the heater element may be configured as an integrated flow control element to form an integrated flow control element. The integrated flow control element simultaneously increases the airflow while adding heat to the airflow, as depicted in Figure 5 (with reference to the following components and corresponding numbers).

Component	*Number*
Primary fan	2
Primary air flow with swirl	3
Secondary fan	4
Flow control element	6
Secondary air flow with swirl	13
External heater element	15
Air flow with reduced swirl	17

(With reference to Figure 5)

The integrated flow control element may be designed to have a number of open channels aligned with the desired flow. Simplistically this may be visualized as a number of tubes aligned with the axis of the fans, and arranged to cover the cross section of the flow channel. However, many designs are possible, and the diffuser element should be carefully optimized for any given application in order to maximize the reduction of swirl and minimize incremental drag within the required operating range(s).

The integrated flow control element may be most effectively placed at a distance from the primary fan, i.e. after some of the swirl produced by the primary fan has naturally subsided. The natural rate of reduction of swirl, without the aid of the integrated flow control element, will be relatively rapid immediately after the primary fan, especially in ducts or shrouds with interior features configured to "straighten" the flow. Further, the amount of swirl as seen at the input of the integrated flow control element may be reduced, for a given flow rate, by applying more power to the secondary fan relative to

the primary fan in order to increase the "pull" effect of the secondary fan relative to the "push" effect of the primary fan.

The primary benefits of heater fans with integrated flow elements is that they are compact, and they may be used to efficiently heat a large interior space. The underlying reason behind the compact size is the fact that the two series fans have a much smaller diameter than the single fan that would be required to produce the same airflow. Heating efficiency is increased by the fact that the integrated heater element is located in a contained air stream, and the heater has been configured such that substantially all of the airflow produced by the primary fan must pass through the heater element before it reaches the secondary fan.

The smaller fan size also means, however, that the airflow produced by the heater is very focused and direct. While this maybe an advantage for industrial heaters, it may not be as desirable for household heaters where the heat must be dispersed. Accordingly, various methods have been devised to diffuse and deflect the output stream.

The preceding Figures A and B may also be used to illustrate the impact of a fan failure. If the primary fan fails, then the secondary fan will continue to draw air through the integrated flow control element and "push" it in the same direction. A similar result will occur if the secondary fan fails, except that the air will be "pushed" rather than "pulled" through the diffuser element. The heater will continue to function, although the velocity of the airflow will be reduced. This is an acceptable situation only if the fault mode airflow is sufficient to ensure that the integrated flow control element does not overheat, or if the power applied to the integrated flow control element is reduced to ensure that this is the case.

The principles taught herein are not limited to heaters and may be applied to several other products. In some cases the integrated flow control element may be configured to remove heat from (rather than add heat to) the air to form a cooler or heat exchanger for an air conditioner. Passive applications that do not require heating or cooling include air purifiers and filters, duct based air movers, and leaf blowers. Automotive applications include point coolers for electronic components, turbo chargers, turbo chargers with inter coolers, cabin heaters and air movers, and the like.

Embodiments

Embodiments of the invention are described by way of example with reference to the drawings in which:

Figure 1 provides a section view of a heater fan with integrated flow control element. Figure 2 provides a section view of a heater fan with integrated flow control element configured as a modular humidifier, and,
Figure 3 provides a section view of a heater fan with integrated flow control element configured as a tube fan.

FIG. 1 provides a section view of heater fan with integrated flow control element 1 with primary fan 2 and secondary fan 4. Primary fan 2 and secondary fan 4 may be identical or dissimilar axial fans, commonly referred to as muffin fans, or any other type of fan suitable for this purpose. Further, primary fan 2 and secondary fan 4 may be configured to rotate in the same or opposite directions. Further, primary fan 2 and secondary fan 4 may be connected to one common fan motor, although some reduction in efficiency may be experienced with this particular configuration.

Integrated flow control element 6 is positioned downstream from primary fan 2 in order to substantially remove the swirl component from the flow generated by primary fan 2, resulting in the efficient operation of secondary fan 4. Integrated flow control element 6 may be positioned a distance from primary fan 2 in order that some initial reduction of swirl may take place prior to integrated flow control element 6. Integrated flow control element 6 may be positioned relatively closer to secondary fan 4 since a substantial amount of swirl will have already been removed from the flow as it leaves integrated flow control element 6, and a further separating distance would have a minimal effect on further reductions of swirl. However it has been observed that a small distance between integrated flow control element 6 and secondary fan 4 reduces the acoustic noise produced by heater fan with integrated flow control element 1.

Primary fan 2 and secondary fan 4, when configured with integrated flow control element 6 in this manner, may produce a level of airflow which approaches the maximum level of

airflow possible with two independent fans similar to primary fan 2 and secondary fan 4, i.e. the theoretical two fan limit, since both fans are operating efficiently. As a result, output airflow 5 may be produced with two fans having a much smaller diameter than the single fan that would be required to produce the same level of airflow. This allows heater fan with integrated flow control element 1 to be very compact relative to its expected output, making very small applications, such as micro heaters that are compatible with track lights, a very real possibility. Alternatively, previously large and bulky heaters, such as industrial or basement heaters, can now be designed on a much smaller scale.

Deflector vanes 7 may be adjusted by the user to direct output airflow 5 in the desired direction. Further, deflector vanes 7 may be automated to "sweep" the air back and forth, thereby covering a much larger area. Alternatively, deflector vanes 7 may be rotated; either mechanically through a geared or direct connect with one of the fan motors, or passively as a result of the thrust produced by output airflow 5 as it passes through deflector vanes 7 having been designed to rotate freely and to produce thrust for this purpose. A lock may be provided to prevent the rotation or movement of deflector vanes 7, in order to produce a focused and constant airflow when required.

Integrated flow control element 6 may be configured as a heating element to add heat to the airflow as it passes through heater fan with integrated flow control element 1. Alternatively, integrated flow control element 6 may be configured as a cooling element to remove heat from the airflow as it passes through heater fan with integrated flow control element 1. Further, integrated flow control element 6 may also be configured as an ionizer to purify and treat the airflow as it passes through heater fan with integrated flow control element 1. However it should be noted that an integrated flow control element 6 configured to provide this type of additional functionality may have a negative effect on efficiency of the airflow because of increased drag.

Primary fan 2, secondary fan 4, and integrated flow control element 6, are surrounded by shroud 8. Shroud 8 is open at the front, to allow air to flow into primary fan 2, and open at the back, to allow for the production of output airflow 5. Further, shroud 8 may be designed to contain the flow, with interior features such as longitudinal ridges designed to reduce swirl as the flow moves from primary fan 2 to integrated flow control element 6. Shroud 8 may also be configured to accommodate air filter 9 and deflector vanes 7. Air

filter 9 may be designed to remove unwanted particles and other impurities from input airflow 11, thereby increasing the quality of output airflow 5 and preventing the unnecessary build-up of dirt and dust on primary fan 2, secondary fan 4, integrated flow control element 6, and the other internal components.

FIG. 2 provides a section view of a heater fan with integrated flow control element 1 configured as a modular humidifier. Shroud 8 may be configured to rest upon and securely mate with reservoir 22, which contains a supply of water 24. Wicking pad 11 may be configured to extend down into water 24, and draw the water up into shroud 8 where the moisture can be absorbed by output airflow 5. Note that output airflow 5 will have been preheated by integrated flow control element 6, increasing its ability to absorb moisture and carry it into the surrounding air. Various other configurations are possible, including a top mounted reservoir 22.

FIG. 3 provides a section view of a heater fan with integrated flow control element 1 configured as a tube fan, or pole fan 30. In this case shroud 8 (reference FIG. 1) has been replaced by pole shroud 33, which may be fixed or telescopic. Air filter 9, primary fan 2, integrated flow control element 6, and secondary fan 4 may be configured within pole shroud 33, as previously described. Pole shroud 33 may be configured to rest on base 31, allowing lower airflow 32, and to support top 34, allowing upper airflow 38 and further supporting light 36. Light 36 may be conveniently used for reading or general illumination purposes.

Pole fan 30, as illustrated, is configured for summer use. In this case no power would be applied to integrated flow control element 6 so that the heat would be added to lower airflow 32 as it passes through interacted flow control element 6. The purpose of pole fan 30 in this mode is simply to draw in lower airflow 32, which is cooler because it is closer to the floor, and to expel it as upper airflow 38. Top 34 may be configured to rotate, providing an enhanced level of circulation. The air within a room may be de-stratified in this manner, and in this sense pole fan 30 provides similar functionality to a ceiling fan. However pole fan 30 is much more compact and much easier to install than a traditional ceiling fan.

Pole fan 30 may easily be reversed for winter use, either by inverting pole fan 30, inverting the heater fan with integrated flow control 1 within pole fan 30, or through some other convenient means. Alternatively, sufficient space may be left between secondary fan 4 and integrated flow control element 6 such that configuration will operate efficiently when the fans are reversed.

Once the airflow has been reversed, pole fan 30 will draw in air at the top, heat it, and then expel it at the bottom. The warm air will then spread over the floor area within a room, and rise again through natural convection. Again, the air within the room becomes de-stratified as a result. Top 34 may be configured to draw the incoming air past light 36, recovering the extra heat produced by the bulb and increasing efficiency. Further, base 32 may be configured to rotate or otherwise dispel the heated air across a greater portion of the floor area within the room.

Pole fan 30 may be configured with a reservoir and a wicking system, similar to the wicking system illustrated in FIG. 2, to provide some level of humidification while in winter mode. Further, pole fan 30 may be configured with some means to remove heat from the air, either through an integrated flow control element 6 adapted for cooling, or through a replaceable "cold" thermal battery, or through some other means, to provide some level of cooling while in summer mode.

The concepts behind pole fan 30 may be applied to other similar products such as duct based air movers, with or without integrated heat boosters, to equalize the distribution of fresh air and heat throughout a home or other building. On a smaller scale the concepts and components described herein may be used to configure a very lightweight hair blower / dryer that does not need to conform to the traditional "pistol" format. On a larger scale they may be used to configure a very lightweight leaf blower, although the heater component would not necessarily be required for this application.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Certain adaptations and modifications of the invention will be obvious to those skilled in the art. Therefore, the above-discussed embodiments are considered to be illustrative and not restrictive, and any and all

changes that come within the meaning and range of equivalency of the embodiments are therefore intended to be embraced therein.